Relationships between individual digestion efficiencies and gut anatomy in broilers from experimental D^+ and D^- Digestion lines or from commercial strains.

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Summary
Calculations were performed using a combination of data from 5 previous studies conducted in broilers from the experimental D^+ and D^- Digestion lines (n=432) observed during their selection process on 3rd, 5th, 6th, 7th and 8th generation, or from 3 previous studies with broilers from commercial strains (n=118). In each experiment, individual diet (wheat or maize) AMEn values or protein digestibilities (PD) were measured at 3 weeks. Weights of empty gizzards and small intestines relative to body weight (G and I, respectively) were also measured at various ages from 22d to 62d. Phenotypic correlations between recorded traits were performed on data corrected for diet and age effects. In birds from Digestion lines, AMEn values were positively correlated to G (r = 0.32; 0.24) and G/I (r= 0.57; 0.42) and negatively correlated to I (r = -0.79; -0.46), with wheat and maize diets, respectively. In contrast, no significant correlation was found between AMEn and G in commercial birds. However, in commercial birds fed wheat diets, AMEn was also negatively correlated to I (r = -0.41) and positively correlated to G/I (r =0.32). PD was positively correlated to G (r = 0.35; 0.28) and G/I (r = 0.47; 0.36), and negatively correlated to I (r = -0.36; -0.17) in birds from Digestion lines and commercial strains, respectively. Cereals (wheat *versus* maize) did not affect regressions between PD and anatomic data neither in Digestion lines nor in commercial strains.
Keywords: broiler, gizzard, intestine, digestion, AMEn, genetics

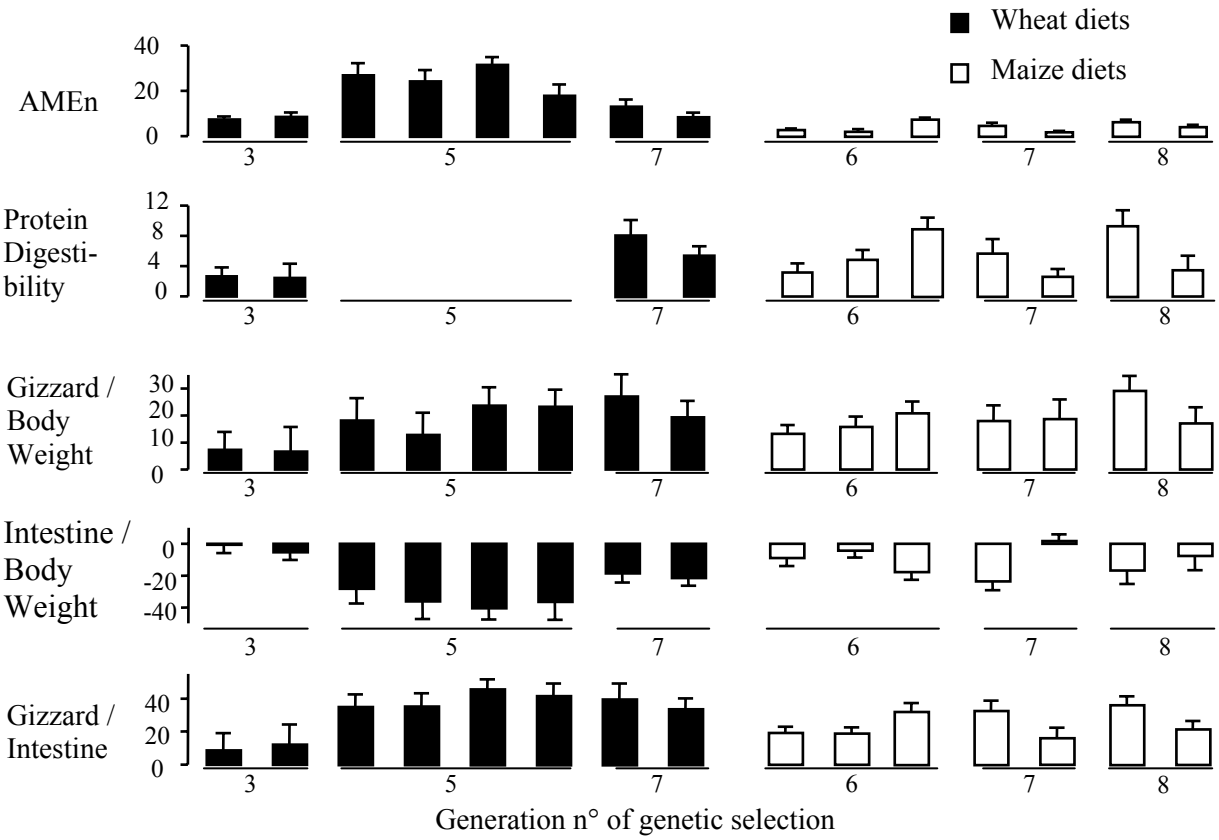
Introduction
Variations in digestion efficiencies were reported to be associated with variations in gut anatomy (Péron *et al.*, 2006; García *et al*., 2007; Rougière *et al*., 2009; Rougière and Carré, 2010). Most of these relationships were observed in genetic Digestion lines selected for divergent digestion efficiencies (Péron *et al.*, 2006; García *et al*., 2007; Rougière *et al*., 2009; Rougière and Carré, 2010). It remains to be known whether such relationships also exist in commercial broiler populations. So, the aim of the current study was to combine our three previous experiments conducted in commercial broilers (Maisonnier *et al*., 2001; Carré *et al*., 2005a; Péron *et al*., 2005) in order to investigate such relationships using a high number of birds. In the current study, relationships obtained in broilers from Digestion lines were also examined by combining data from all our previous studies conducted in these birds (Carré *et al*., 2005b; García *et al*., 2007; Rougière *et al*., 2009; Rougière and Carré, 2010; Mignon-Grasteau *et al*., 2010), in which digestion efficiencies and relative weights of gizzard and intestine were measured. Thus, a comparative approach between broilers from commercial strains and those from Digestion lines was developed in the current study.

Materials and methods
All individual data from our laboratory reporting dietary AMEn values, total apparent protein digestibility (PD), gizzard and intestine weights relative to body weights in broilers from commercial strains (Maisonnier *et al*., 2001; Carré *et al*., 2005a; Péron *et al*., 2005) or from

D^+ and D^- Digestion lines (Carré *et al*., 2005b; García *et al*., 2007; Rougière *et al*., 2009; Rougière and Carré, 2010; Mignon-Grasteau *et al*., 2010) were combined in a common file, with diet (33 different diets), age (continuous variable), cereal (wheat or maize) and genetics (commercial strain or Digestion lines) factors being associated to each individual data.
In these studies, all AMEn and protein digestibility data were obtained at about 3 weeks of age. Gut anatomic data were all obtained between 3 and 4 weeks of age in broilers commercial strains, while those from Digestion lines were obtained at various ages up to 63 days of age.
Statistical calculations of relationships between digestion efficiencies and gut anatomic data were only performed on individual variations. For that purpose, AMEn values and protein digestibilities were corrected for diet effect. Anatomic data in broilers from commercial strains were also corrected for diet effect. Anatomic data for Digestion lines were corrected for both diet and age effects.
Statistical analyses were performed with the SuperAnova software (Abacus Concepts, Inc), applying the type III technique for the calculation of sums of squares.

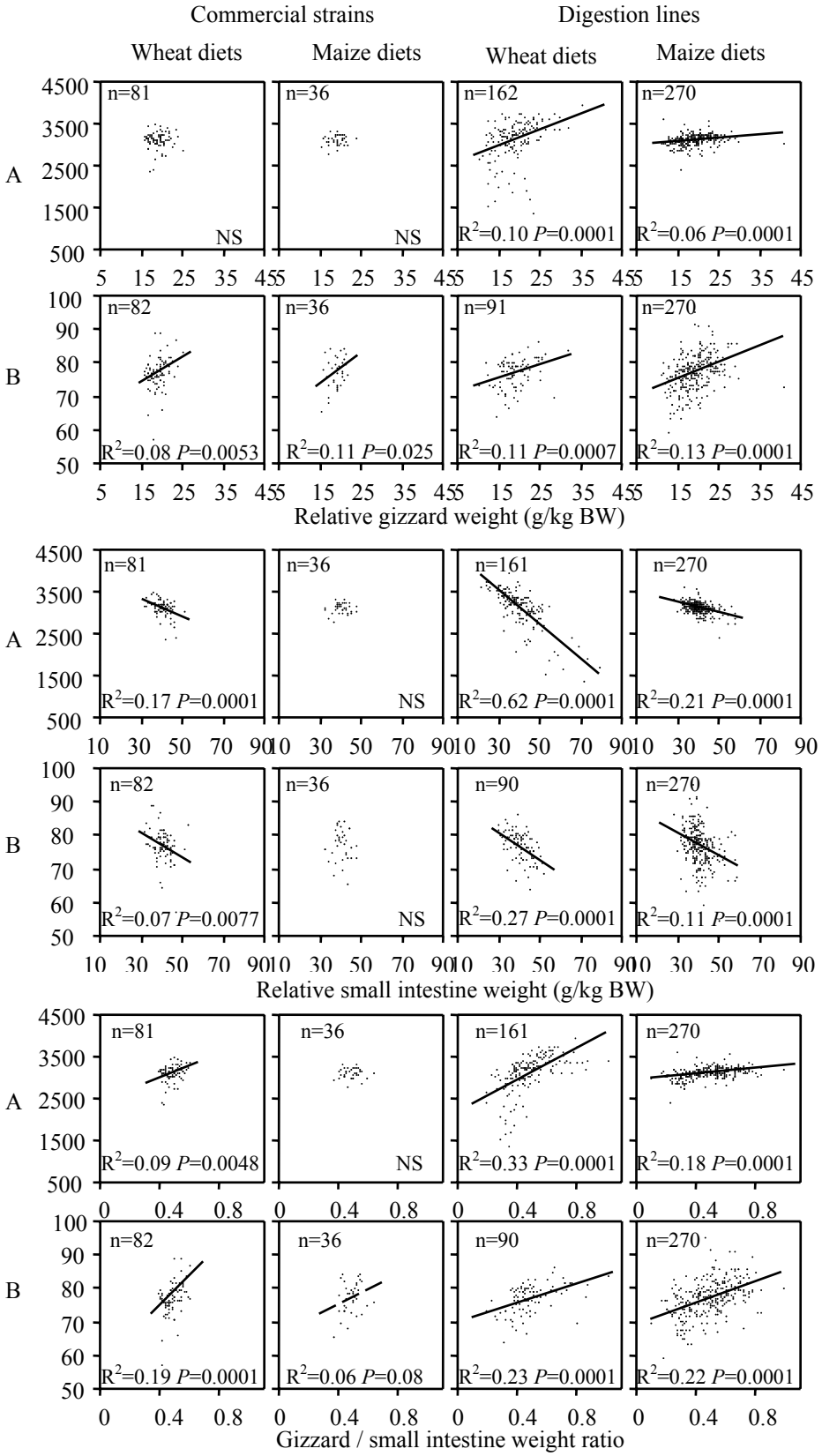
Results and discussion
In all cases, gizzard was bigger and intestines smaller in D^+ than in D^- birds, which resulted in about 30% higher G/I ratio in D^+ than in D^- birds (Figure 1). Combining all data from Digestion lines observed in previous experiments (Carré *et al*., 2005b; García *et al*., 2007; Rougière *et al*., 2009; Rougière and Carré, 2010; Mignon-Grasteau *et al*., 2010), relationships

Figure 1. Relative differences (%) between D^+ and D^- lines[1] [$(D^+ - D^-)/D^+$; means and SE].



[1]Data were derived from Carré *et al.* (2005b), Garcia *et al.* (2007), Rougière *et al.* (2009), Rougière and Carré (2010) and Mignon-Grasteau *et al.* (2010).

Figure 2. Relationships between individual digestion efficiencies (A: AMEn (kcal/kg DM); B: protein digestibility (%)) in 3 week broilers[1], and individual gut anatomy. Digestion efficiencies were corrected for diet effects. Gut anatomic data were corrected for diet and age effects.



[1]Data were derived from Maisonnier *et al*. (2001), Péron *et al*. (2005), Carré *et al.* (2005ab), Garcia *et al.* (2007), Rougière *et al.* (2009), Rougière and Carré (2010) and Mignon-Grasteau *et al.* (2010).

between individual variations of digestion efficiency and gut anatomy were all highly significant (P< 0.001) (Figure 2), with relationship patterns similar to those observed in previous experiments (García *et al*., 2007; Rougière *et al*., 2009; Rougière and Carré, 2010). In broilers from Digestion lines, slopes observed for AMEn values were more pronounced with wheat than with maize diets, while, for protein digestibility values, slopes did not differ between wheat and maize diets (Figure 2).
In broilers from commercial strains (Maisonnier *et al*., 2001; Carré *et al*., 2005a; Péron *et al*., 2005), the number of birds examined was not very high, especially with maize diets. So, the relationships were often not significant (Figure 2). However, with wheat diets, most of the relationships were significant and showed trends similar to those observed in Digestion lines, with positive relationships regarding gizzard and G/I ratio, and negative relationships regarding intestine (Figure 2). The slopes of the line relating AMEn to G/I did not differ between Digestions lines and commercial strains (Figure 2). However, the lines relating PD to G/I showed higher slope values for commercial strains than for Digestion lines. Slopes of the lines relating PD to gizzard or intestine weights did not differ between bird types (Figure 2).
So, relationships between digestion efficiencies and gut anatomy observed in birds from commercial strains showed many similarities with those observed in Digestion lines. This suggests that the sources of variations in digestion efficiencies were probably similar in both bird populations.

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